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CORN BREEDING AND REGISTRATION.

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The basis upon which corn breeding and registration rests is the ear-row test. This test, when wisely and carefully conducted, is a very satisfactory method of determining the comparative yielding ability of ears of corn. In making one's selection of ears for this test it is probable that some time and labor may be saved, *i. e.* some ears of little value may be kept out of the test, if the selections are made as the corn is ripening in the field.

Good ears of corn are what they are as a result of either heredity or environment. Selected apart from the growing plant, the chances for choosing ears, which owe their excellence to heredity, are not the best. Most especially productive plants owe their superiority to immediate environment. Extra food, sunlight and moisture, resulting from thin stand, are responsible for many more large ears of corn than is heredity. When selections are confined to the best plants and ears obtainable, which have been grown under normal environment, a pronounced step is taken in the direction of sifting out the temporarily and accidentally good from the inheritably good. "Natural selection" De Vries tells us, "is a sieve." So is all selection.

GERMINATION.

Several weeks in advance of planting, all candidates for the ear-row plot should be given a germination test. With early selection and wise handling of seed ears, however, there is little weeding out likely to be accomplished. While the germinator will pick out half-dead ears, it is hardly able to distinguish as between a Dan Patch and a 4-minute roadster, or between a Shakespeare and a curtain-dropper. It serves its purpose in keeping the half-dead ears from cumbering the ground.

A paper read at a joint meeting of the American Breeders' Association and the Ohio Plant Breeders Association, at Columbus, Ohio, January 16, 1907, and published at the request of the latter Association.

RECORDS.

It is well to record quite minute details as to the characters of the ears going into the test, and of the mother plants as well. Such data may prove exceedingly valuable in making correlations, when we have accumulated enough of them. I hesitate to burden this paper with the enumeration of some seventy different headings under which we aim to record data, beginning with the mother plant in the field the year previous, and ending with the harvest of the ear-row test. I must not, however, fail to mention the photographing of each ear tested.

PLANTING

The ear-row test may be planted without any regard to other corn fields. A convenient place may usually be found in connection with the general crop field. The important thing in locating this plot is the selection of soil of uniform fertility, level or of uniform slope, and so laying it out that all rows shall be equally affected by tile drains, surface ditches, dead furrows, etc.

This is more easily said than done upon many Ohio farms. If it could be carried out with absolute exactness, an absolutely reliable test would result. Differences in yield which were then found, could, if subsequent work were as carefully conducted, be ascribed to heredity. But practically it is not possible to do all this. Some known and very many unknown differences exist; differences which make it exceeding difficult to distinguish as between hereditary and environmental merit. Our experience, both at the Station and in our cooperative work with corn breeders in various parts of the state, has convinced us of the value of the duplication of the ear-row test and the use of the uniform check row.

The method of planting a duplicate ear-row test, having uniform check rows, is as follows: Assuming for convenience that 25 ears are going into the test, 61 rows will be required, eleven of which will be checks. Beginning with a check, every sixth row, throughout the test, will be planted as a check.

In planting the check rows, the number of ears necessary having been determined, they are shelled and kept separate and the same number of hills (and kernels) planted from each check ear upon each check row. Between each pair of checks are 5 rows, or 50 rows in all, exclusive of the checks. These 50 rows are planted consecutively with the 25 ears to be tested, rows 1 and 26 being planted from ear 1 (disregarding the check rows for the time being) 2 and 27 from ear 2, etc., etc. The rows are usually 50 hills in length.

It is not necessary that the duplicate series be planted immediately following the original. It may be taken to another part of the farm.

It yet remains to call attention to the great desirability of growing and harvesting the same number of plants on each row. With 100 plants in one 50 hill row and 175 in another we have unnecessarily increased the difficulty of arriving at correct conclusions.

The germination test will not always save us from an uneven stand, for the fact that an ear of corn has shown perfect germination, as ordinarly tested, is by no means proof that every kernel will grow under unfavorable field conditions. In order to be able to thin to a uniform stand of plants per hill after the losses from bad weather, insects, birds, etc., are over, and the corn 6 to 8 inches high, it will be found necessary to plant liberally. The planting is, of course, uniform throughout the test. Usually from one-half to two-thirds of the seed grain of each ear is used in planting the two rows of 50 hills each, the balance of the seed of each ear being carefully saved in a small sack bearing the same number as the ear, for possible future use.

Data are recorded, as the season progresses, regarding the number of plants coming up in each row, rapidity of early growth, proportion of leaves, character of leaves, date of tasseling, date of silking, height of plants, height of ears, number of smut masses, number of broken plants, number of barren plants, number of useless plants, number of plants with two or more ears, number of suckers, date of ripening, total number of plants harvested, etc.

Each row is harvested separately, the weight of the marketable and unmarketable corn determined, and the comparative rank of the mother ears as to yield established.

You may be interested in looking at a few curves showing the results secured by some of the members of our Ohio Plant Breeders' Association, and especially the bearing of the duplication of the work upon the selection of high yielding ears.

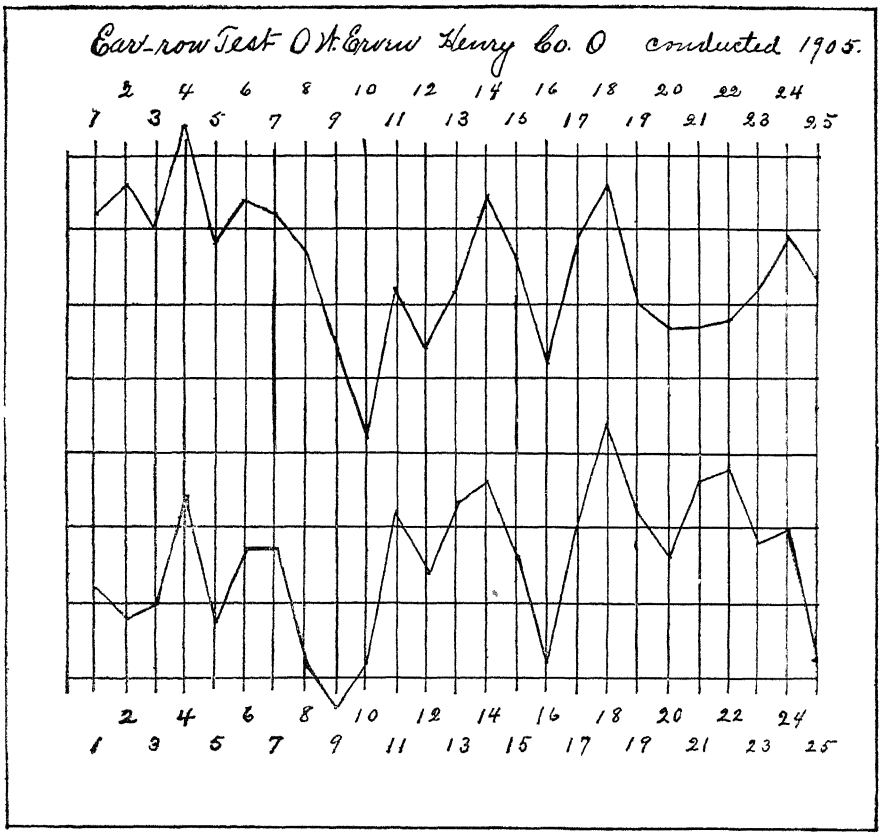

CHART I.

CHART I—We have here curves showing the comparative yields of a duplicate ear-row test conducted by O. W. Erven, of Henry County, in 1905. Basing the selection on the upper curve, you note that ears 4, 2, 18, 14 would be chosen; based upon the lower curve, ears 18, 22, 21 and 14. It is evident that selections based upon either curve by itself (and this would have to be done but for the duplicate) will hardly be as satisfactory as selections based upon both. Averaging the curves, ears 18, 4, 14 and 22 rank highest.

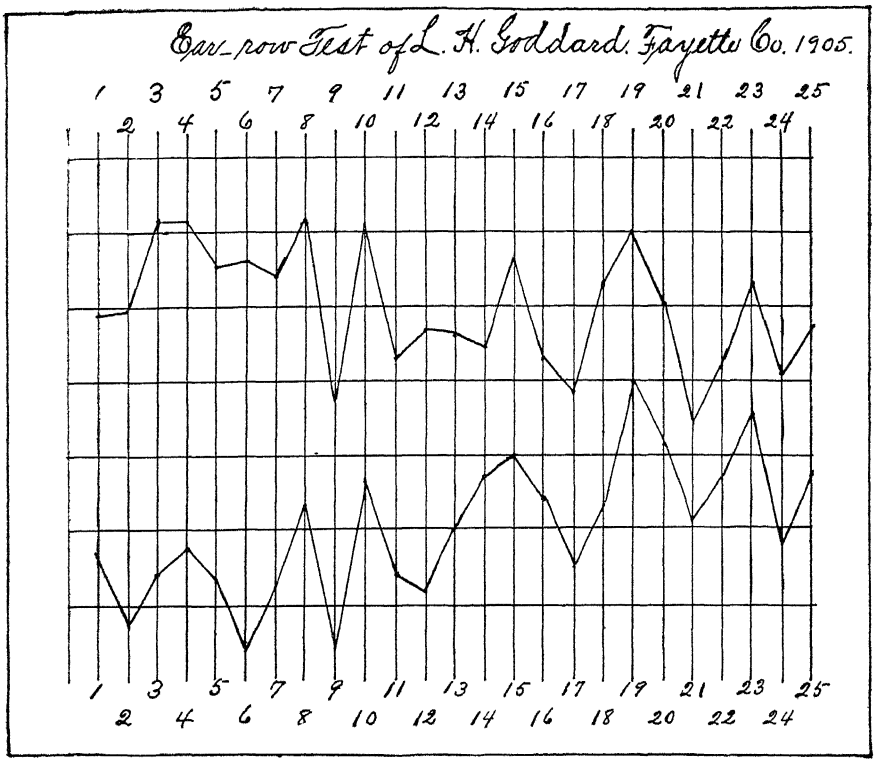

CHART II.

CHART II.—We have here a test conducted by L. H. Goddard, of Fayette County, in 1905, which was greatly injured by wet weather and which probably would have been abandoned had it not been for the duplication. You will note that the first curve tends downward, while the second curve, planted from the same ears and in the same order, tends decidedly upward. The two series were planted consecutively, the second series fitting on,—so to speak—at the right of the first. The ground being slightly lower in the center, two weeks of continuous rain, coming at a critical period, seriously injured the right of the upper curve and the left of the lower. Taking the two curves together it is not very difficult to select three or four ears of much higher grade than the others.

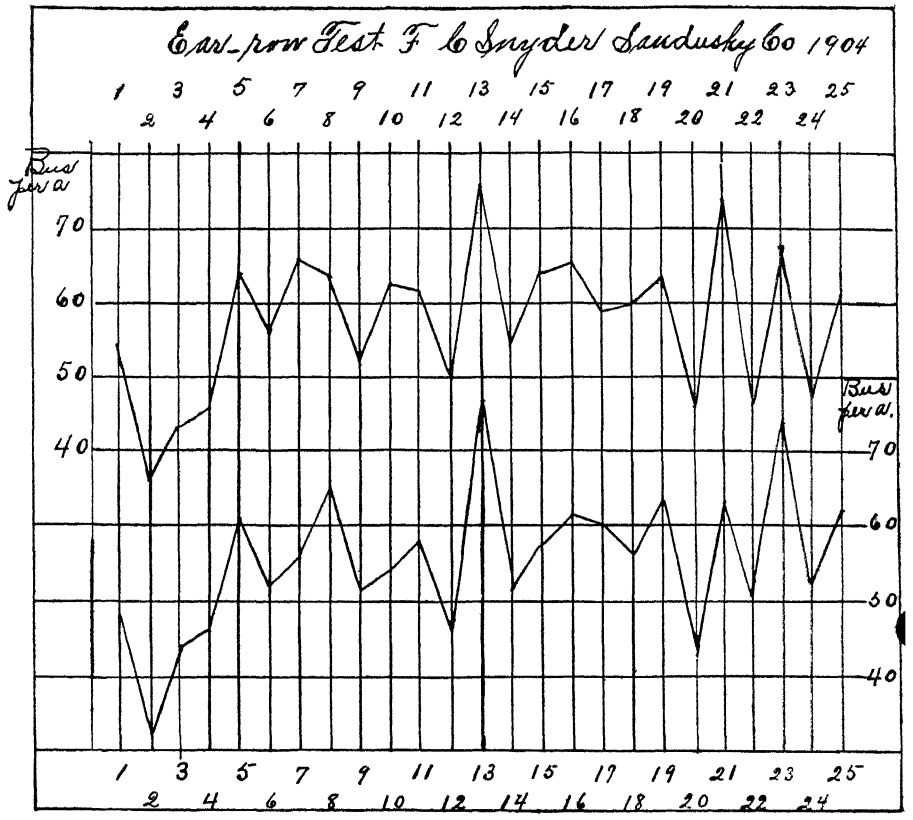

CHART III.

CHART III.—In Chart III we have the work of F. C. Snyder, of Sandusky County, an ear-row test conducted in 1904. These curves give evidence of careful work and very even ground. The verdict of the first series is in favor of ears 13, 21, 23 and 7; of the second series, 13, 23, 8 and 19 or 21. The chances of making mistakes here without duplication are less than in either of the others shown, yet even here, I think, we gain something by the duplication.

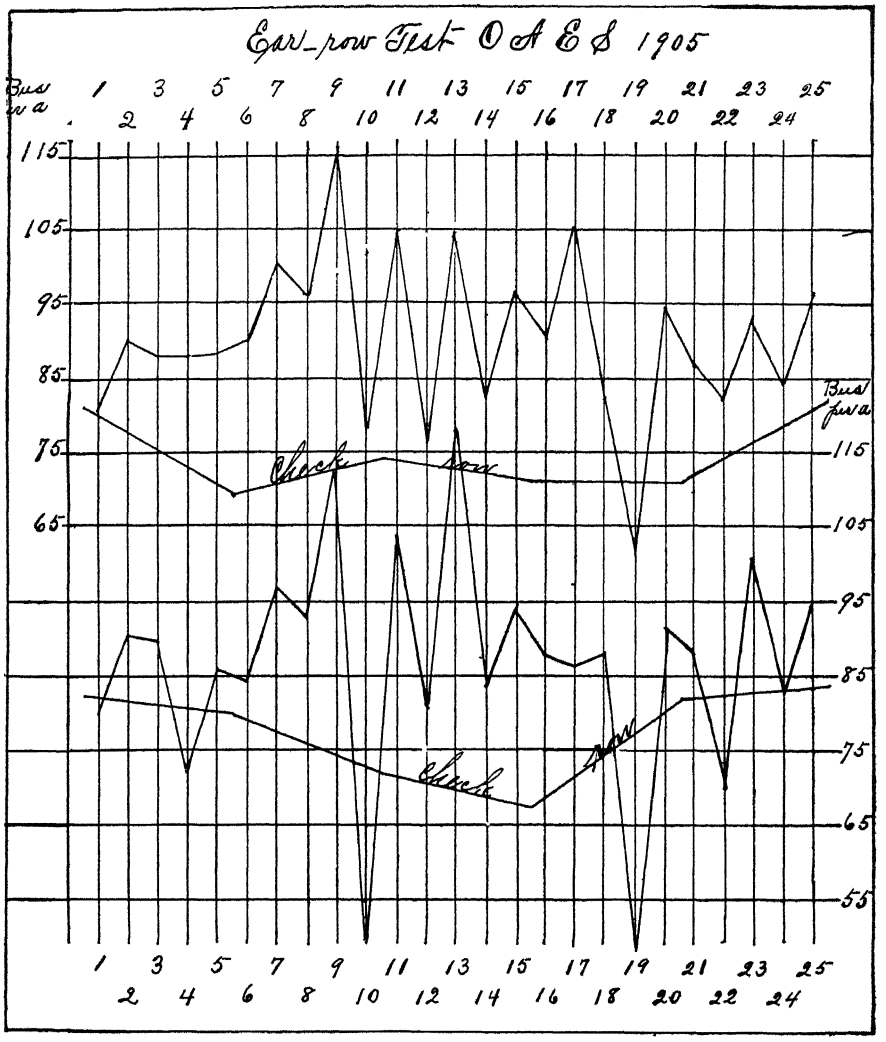

CHART IV

CHART IV—On this chart we have shown a test in which the check row was used. This check row serves to show some unevenness in the environment but fails to account for the two radical variations observed in ears 4 and 17. Without duplication, the first series would have elected ear 17 to the select circle, but the second series vetoes this. Ear 23, which stands forth in the second series, occupies a much inferior position in the first series, while ear 7, which stands fifth in each, will on the average of both, take fourth place.

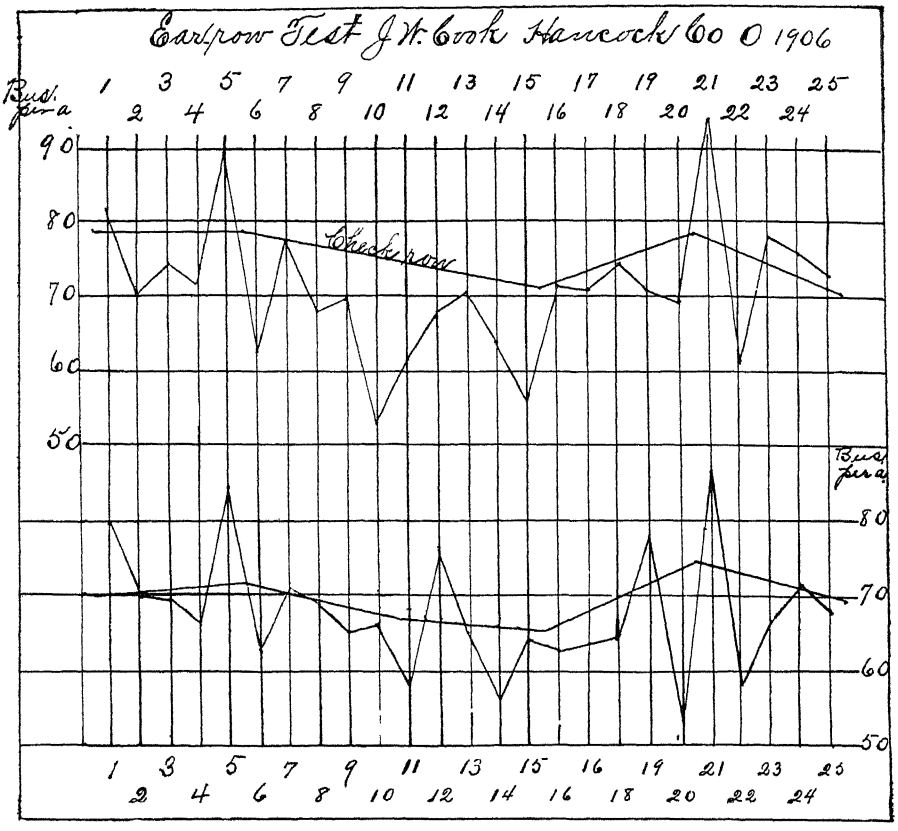

CHART V.

CHART V.—J. W. Cook, of Hancock County, has a test this year in which the value of duplication is quite apparent even when a uniform check row is used. In this test, you will note that the check rows show a surprising uniformity in the very moderate lack of uniformity in the two series. This test shows two mountain peaks of about the same comparative height above the check in both series —ears 5 and 21. In addition it shows something which I will not undertake to explain, although it is exceedingly important that we find out, viz.; two valleys in the first series—12 and 19—changed to mountains in the second series.

I should not care to save but three ears in this test, but in 21 5 and 1, I should expect I had good value.

It should be said, perhaps, that the difference in yield in ear 12 in the two series was not due to stand. There was one more plant harvested in the first series than in the second. Neither are the

wide differences in yield which you observe, as for instance in ear 21 as compared with ear 10, due to number of plants harvested, for there were five more plants harvested on 10 than on 21. The differences between these ears, I believe, are internal, not external. Internal and eternal!

It would seem quite evident that the ear-row test furnishes a means of selecting ears of inherent value. Having discovered such ears the question now confronting us is, how may they be perpetuated with greatest advantage?

Two methods are in use. In the first, selections of choice ears are made directly from the ear-row test. Certain seed ears having demonstrated their ability as producers, their progeny is selected directly from the row, subject of course to more or less cross-pollination from much less desirable ears.

In the second, recourse is had to the original remnants of the ears, as planted in the test. The test having shown which are the high yielding ears, their breeding is thus made possible. Accordingly the following season the best of them are crossed in an isolated breeding plot. This breeding plot is made up of a number of short rows from each ear-remnant used, one only being used as sire, (when natural pollination is permitted) with several others as dams. The ear remnant used as sire is planted upon each alternate row. The ear-remnants used as dams are planted separately, alternating with the sire rows. The latter are the only plants allowed to mature pollen. In this way several distinct strains may be grown in a breeding plot, all having, of course the same sire—strains having a performance record for both sire and dam.

The theoretical advantage of this second method of breeding is being accepted by some breeders. The actual demonstration of its value will require several years yet, although evidence in its favor is gradually accumulating.

For instance, we had this year at the Ohio Experiment Station tenth-acre plots of corn growing in our variety corn test, illustrating both methods of breeding. The one, a strain of Leaming corn, bred by Mr. F. C. Snyder, of Sandusky County, who had crossed (merged) the remnants of the best ears of his 1904 ear-row test, in an isolated breeding plot in 1905, and furnished us seed for tenth-acre plots of both his original Leaming corn and his proposed new "Ohio Standard Leaming," as our Ohio Plant Breeders' Association styles it. These plots were grown side by side and between our regular variety check plots. **The Ohio Standard Leaming gave a yield of 7.17 bushels per acre in excess of the original Leaming from which it had been selected.**

In the same tenth-acre plot test we had two of what I will call "half-blood" strains of Clarage corn, selected directly from the highest yielding rows of an ear-row test, in which greater superiority was shown on the maternal side than in the case of the Leaming just quoted, These "half-blood" strains were grown by the side of the original stock from which they had been selected and gave an average gain of 2.8 bushels per acre. In other words, the Standard bred strain, in the breeding of which, pollen from the inferior ears of the ear-row test had been eliminated, gave a gain in excess of the "half-blood" strains of over 150 percent.

I wish now to call the attention of the Association to a plan for continuous corn breeding work which the Ohio Experiment Station is following. (See Chart VI).

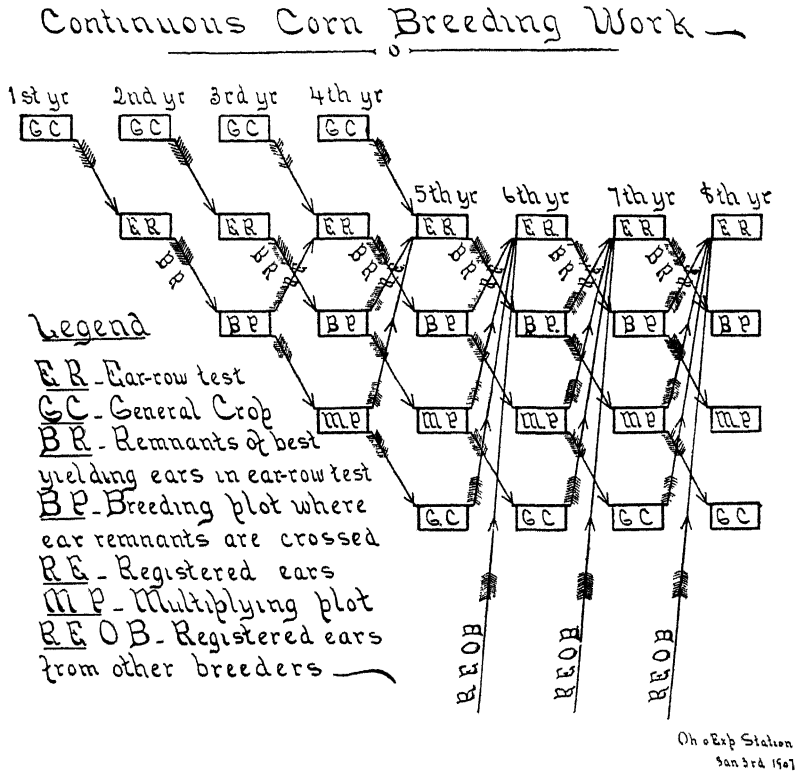

CHART VI.

The first year's work consists of the selection of ears for the ear-row test from the general crop. These ears are given a duplicate ear-row test the following season, and the third year the remnants of the highest yielding ears of the ear-row test of the second year are crossed in the breeding plot. The fourth year a portion of the stock of registered ears will be merged and go into the multiplying plot and the fifth year into the general field crop.

Each year will have its own ear-row test. The ears tested in the ear-row test of the third year all coming, as before, from the general crop. In the ear-row test conducted the fourth year of the work, registered ears from the third year's breeding plot meet the selections from the general crop of the same year. One is thus enabled to test out the results of his breeding work to date. No pedigreed ear is carried from one breeding plot to another simply on the reputation of "pa" and "ma." Those registered ears must go back to the ear-row test, climb the high fence, and, if they succeed, they will be found in the breeding plot of the fifth year. No ear gets into any breeding plot in this system of breeding which has not demonstrated its worth. Of every ear produced in any breeding plot, it is possible not only to name the sire and dam but to give the performance record of sire and dam, and that record, comparatively speaking must be a good one. Take for instance, the breeding plot of the eight year. Of some of the ears found in this plot it will be possible to give the performance record of the sire and dam as tested in the ear-row test of the seventh year; of the grand-sire and grand-dam as tested in the ear-row test of the fifth year and of the great grand-sire and dam as tested in the ear-row test of the third year; and if there are other ears there with a shorter pedigree it will be because they have demonstrated their superiority over those of a longer pedigree.

As the work continues the ear-row test will draw upon the multiplying plots for testing, and, after the fifth year, from a general crop which has decended from pedigreed ears.

But what about the dangers from in-breeding in this system? We do no detasseling in the ear-row test plots. Less than one-sixth of the parent ears represented in any one ear-row test will ever be used for breeding purposes, and which these ears are we do not know until the test is completed. The place to secure cross-breeding of the ears we want cross-bred seems to be in the comparatively small breeding plot, where we can cross intelligently and without detasseling large numbers of plants we really have no use for.

The ears leaving the breeding plot of the third year's work will certainly be as thoroughly cross-bred as ears selected directly from the general crop. In the latter case we would have good reason to believe that they were cross-bred; in the former case we know it. These ears will meet ears from the general crop in the ear-row test of the fourth year's work, and our experience is that some of these new selections will prove worthy competitors of the pedigreed ears.

In our first selections for ear-row testing we choose perhaps 100 ears from a crop of a third of a million ears. It is hardly probable that we secured all the good ones. It is probable that in our successive selections we shall get, not only new, but worthy blood which will work its way into the breeding plot.

There seems to me to be no possibility of any trouble from in-breeding before the sixth year; the ear-row test of this year being the first which draws ears from a general crop which has descended from pedigreed strains, but even then it is very doubtful, for we have three distinct lines of breeding converging into the ear-row plot of this year, as follows: The general crop of the fifth year, which has descended from the first year's selection; the multiplying plot of the fifth year which has descended from the second year's selections, and the breeding plot of the fifth year which has descended, in part, from the third year's selections and has been thoroughly cross-bred as well. This would seem to provide pretty well against in-breeding.

But be this as it may. If in-breeding is feared at this time, or later, there is nothing to hinder our corn breeder from following the custom of the animal breeder. He can go to another breeder, who is breeding corn similar to his own, for new blood. And he can do this with greater safety than the animal breeder, for the latter, when he purchases a sire has no recourse but to use him; to incorporate the new blood into his herd and anxiously wait to see what value it may possess. Whereas the corn breeder can test the producing ability of the registered ears he would use from other breeders beside his own corn in the ear-row test and if it prove inferior to his own corn he can drop it without any contamination. If it prove the equal of his own, or better, the following year it will go into the breeding plot. New blood may be introduced as frequently as may prove necessary.

ISOLATION OF PLOTS.

One of the difficulties confronting the corn breeder is the isolation of breeding plots. A system of breeding which called for a large number of isolated plots would be objectionable. The chart before you (VI) is pretty well covered with corn fields, but as a matter of fact, the only plots calling for isolation are the breeding and multiplying plots, and with some of our smaller growers the multiplying plot will naturally take the place of the general crop. In such cases only one isolated plot will be required each year.

REGISTRATION.

Ohio corn breeders came to a point two years ago where they realized that some system of registration was needed which should do for corn breeders what the so-called systems of advanced registry were doing for some of our dairy cattle associations. A system of registration which should certify both as to ancestry—including of course both sire and dam—and performance records. A committee was appointed to devise such a system, of which Mr. L. H. Goddard, was chairman. This committee carefully studied the systems of our

various live stock registry associations and later recommended the following rules, which were adopted by the Ohio Plant Breeders' Association at their annual meeting one year ago. They are as follows:

RULES FOR THE REGISTRATION OF SEED CORN WITH THE OHIO PLANT BREEDERS' ASSOCIATION.

SECTION 1--ELIGIBILITY.

In order that a strain of corn may be eligible to registry with the Ohio Plant Breeders' Association, it is necessary that it trace directly and exclusively to remnants of ears that have ranked not lower than fourth in point of yield of grain, protein, starch or fat in a duplicate ear-row test of not less than 25 ears, or in like proportion with a larger number of ears; and that each year's breeding or testing work shall have been conducted and recorded in accordance with the requirements af the Association.

SECTION 2—OHIO PEDIGREED CORN.

Any corn which is the product of a cross between two ear remnants, one as sire and the other as dam, each of which has been selected as per Section 1, shall be entitled to the name "Ohio Pedigreed." The records shall show whether the cross was made by artificial or natural pollination.

SECTION 3—OHIO STANDARD CORN.

Eight or more registered ears, as per Section 2, or ear remnants, as per Section 1, may be merged by shelling and mixing together the grain from all, before planting. If this merged corn, or corn descended exclusively from it, shall on the average excel in yield of grain, protein, starch or fat per acre, each of three other varieties (including the one from which it has descended and a standard variety which shall be supplied by the Council upon request) when tested upon not less than tenth-acre plots for three consecutive years, the owner of it shall be entitled to a certificate under the seal of the Association, setting forth the record numbers under which the work upon this corn has been recorded, together with a statement that it has filled the requirements of the Association and is entitled to the name "Ohio Standard."

A fee of $10.00 shall be required for this certificate and copies of same shall be issued at 25 cents each to accompany any corn that traces directly and exclusively to this merging.

SECTION 4—TRANSFERS.

Transfers of grain, together with all breeding privileges, may be made at any time, but in order that the progeny of such grain may be eligible to registry with the Association; each transfer must be entered for registry with the Recording Secretary of the Association within three months of the time of transfer. A certificate of transfer shall then be issued under the seal of the Association, showing the record numbers under which the work of the breeders upon this corn has been recorded.

A fee of $1.00 shall be charged for each record of transfer.

These rules, as you note, provide for the registry of two different sorts of corn; so-called Ohio Pedigreed and Ohio Standard. The Pedigreed corn (referring to the "continuous corn breeding chart") is produced in the animal breeding plots and nowhere else. The Ohio Standard corn is produced in the multiplying plots, and beginning with the fifth year, in the general crop. Before it is entitled to the name and certificate of Ohio Standard it must prove its worth in three consecutive competitive tests.

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